DETAW: A New Model to Estimate Consumptive Water Demands in the Delta

(Based on Asilomar 2006 Presentation "DETAW: A SIMETAW-Based Model to Estimate Consumptive Water Demands in the Sacramento – San Joaquin Delta" by Tariq Kadir DWR, Richard Snyder UCD, and Morteza Orang DWR)

DSM2 Users Group Meeting

April 25, 2006

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DWR Modeling Support Branch

Hydrology and Operations Section

Objectives

- Improve the estimation of ET_{aw} and Net Application for the Sacramento-San Joaquin River Delta
- Consistency between models using same data:
  CALSIM and DSM2

Approach

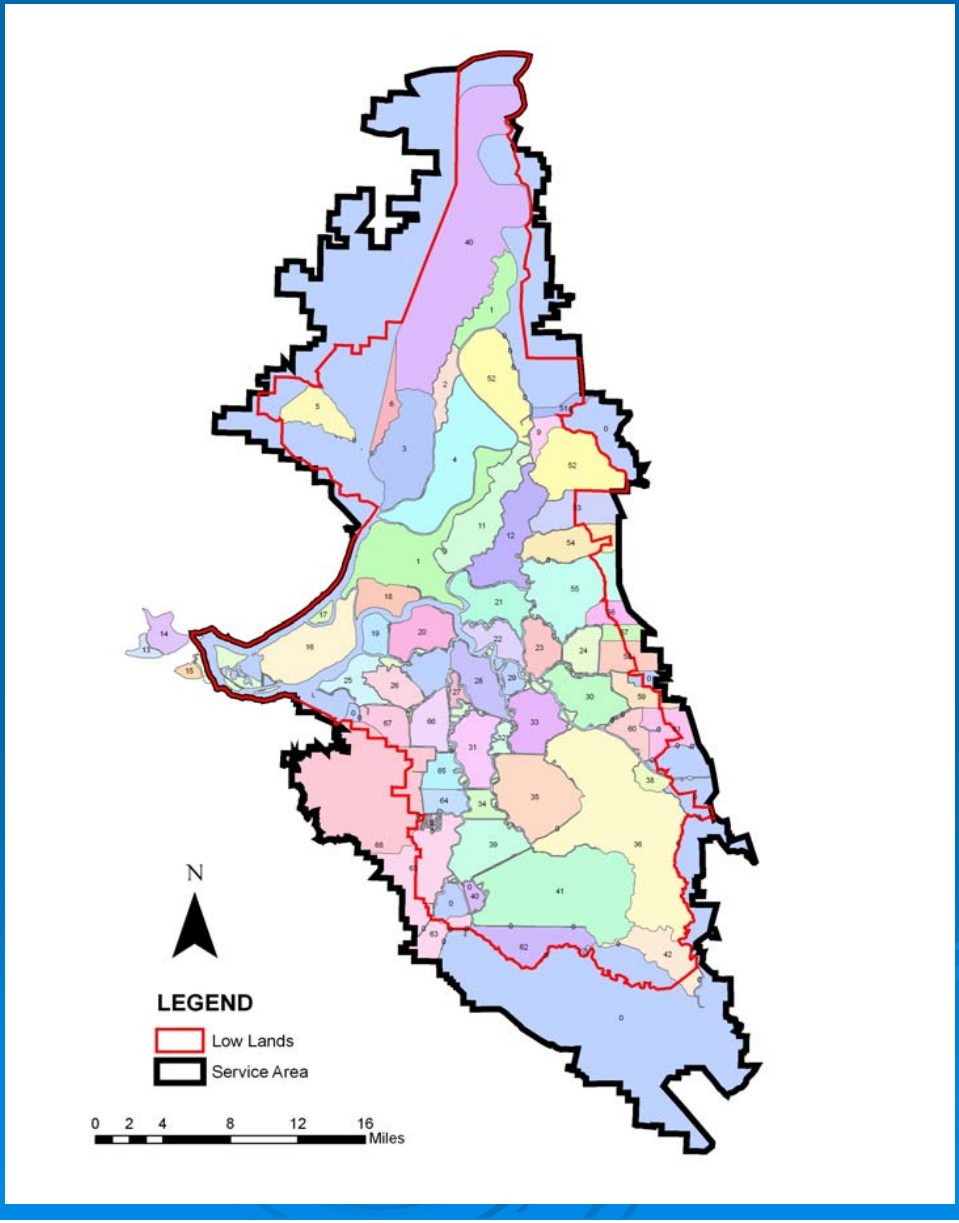
- Use GIS to delineate basic computational units (subareas) that can be aggregated up to the Delta scale
- Use GIS-based surveys (1992-2000) and 1976 for land use patterns to subareas. For historical/projected levels use CU model Lowlands/Uplands totals to disaggregate to subareas
- Estimate daily ET_o rates spatially across the Delta (by subarea) using Hargreaves Samani Equation (temperature based) and correlate with Pennman-Montieth Equation (CIMIS) for WY1922-2003
- Compute daily ET_c rates for 15 land-use categories (agricultural crops, urban, native vegetation, riparian vegetation, open water surface) including off-season and in-season, in each of 168 sub areas.

Approach
(continued)

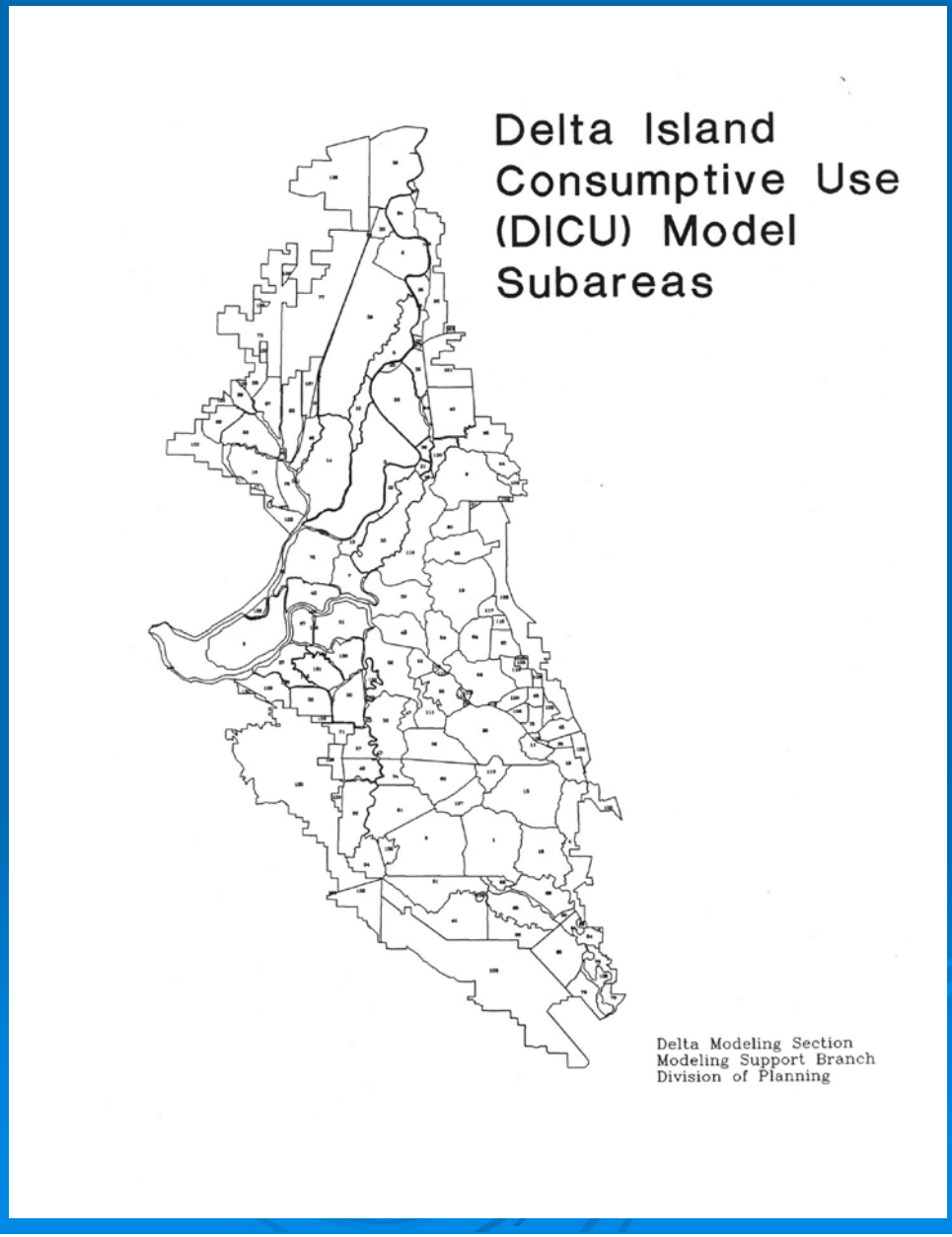
- Make daily soil water balance calculations to estimate seepage contributions, effective rainfall, net applications daily for 15 land surfaces in 168 Sub Areas of the Delta

- Estimate monthly, seasonal, and annual ET_{aw} for the Delta lowlands, uplands and the entire Delta

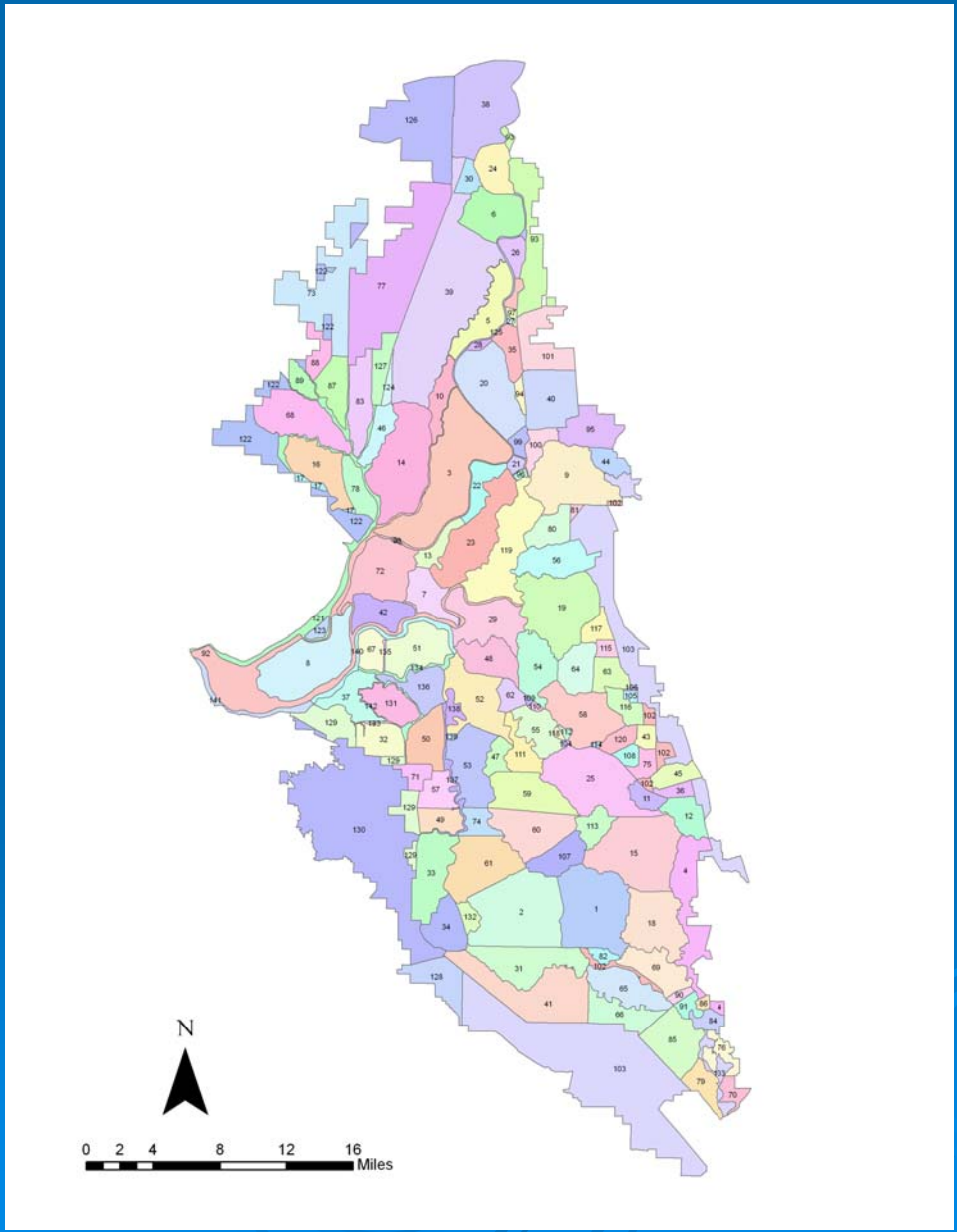
GIS Delta Islands (DWR/DPLA)



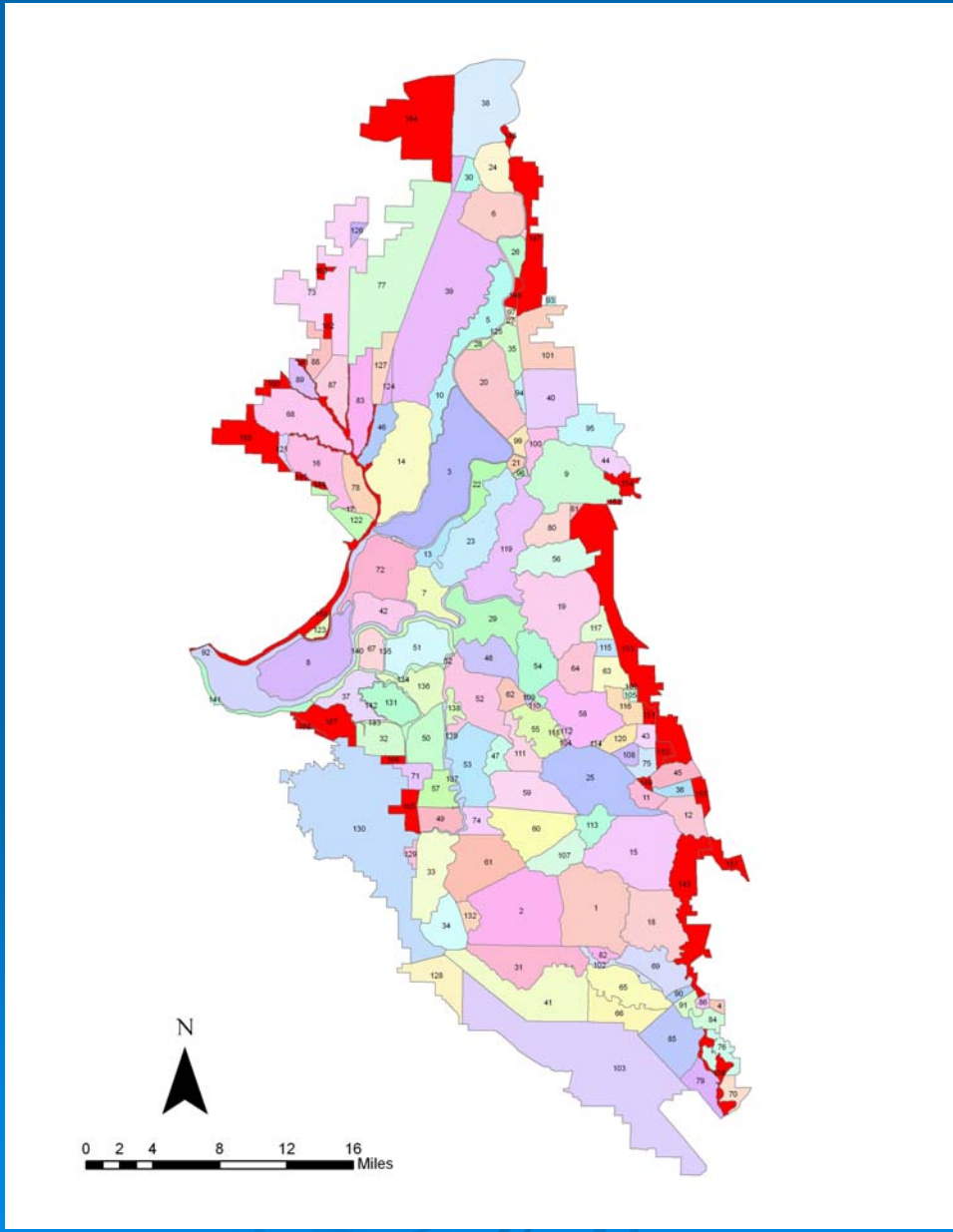
Original 142 Subareas – Scanned Map



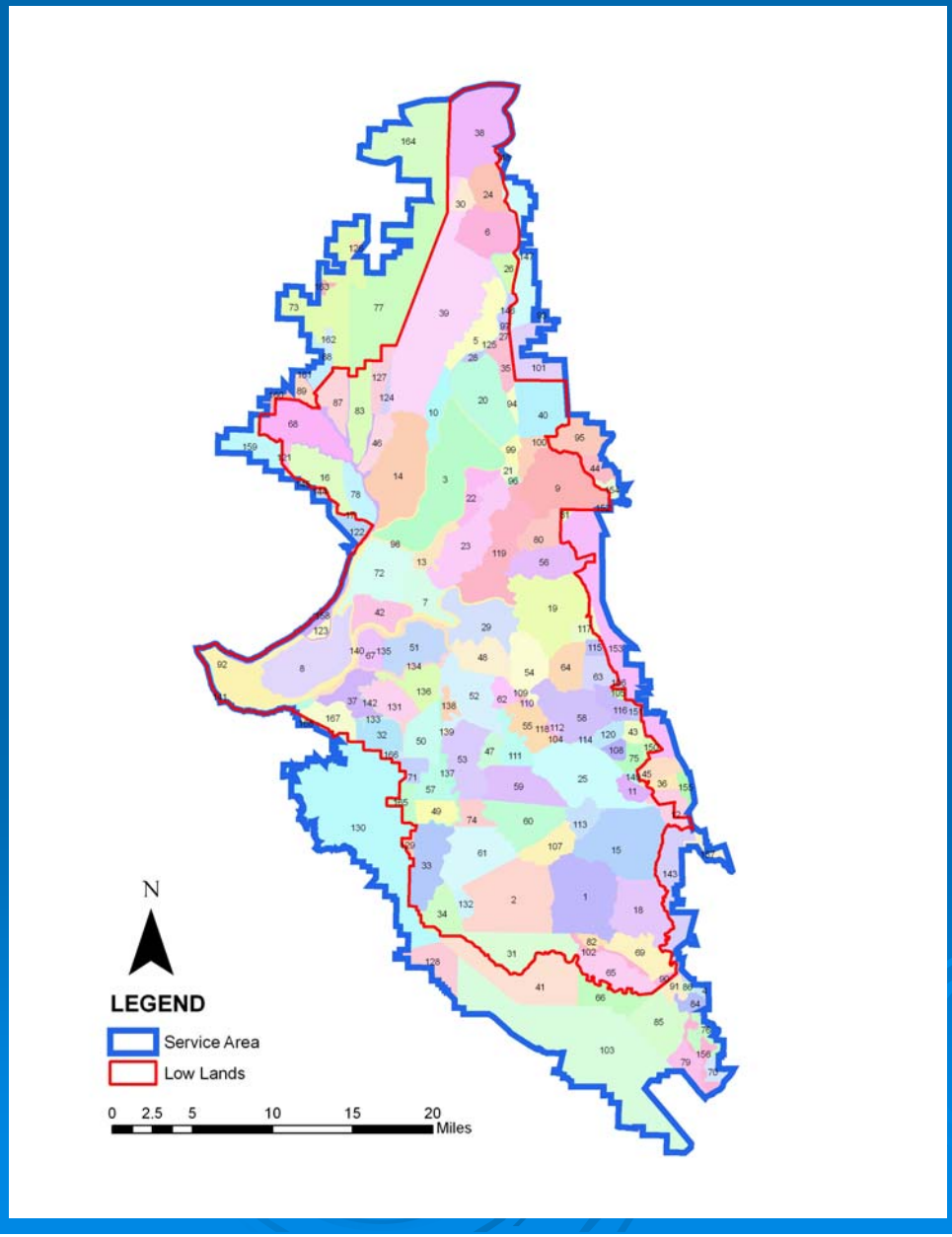
142 Subareas - Digitized



26 Newly Defined Subareas



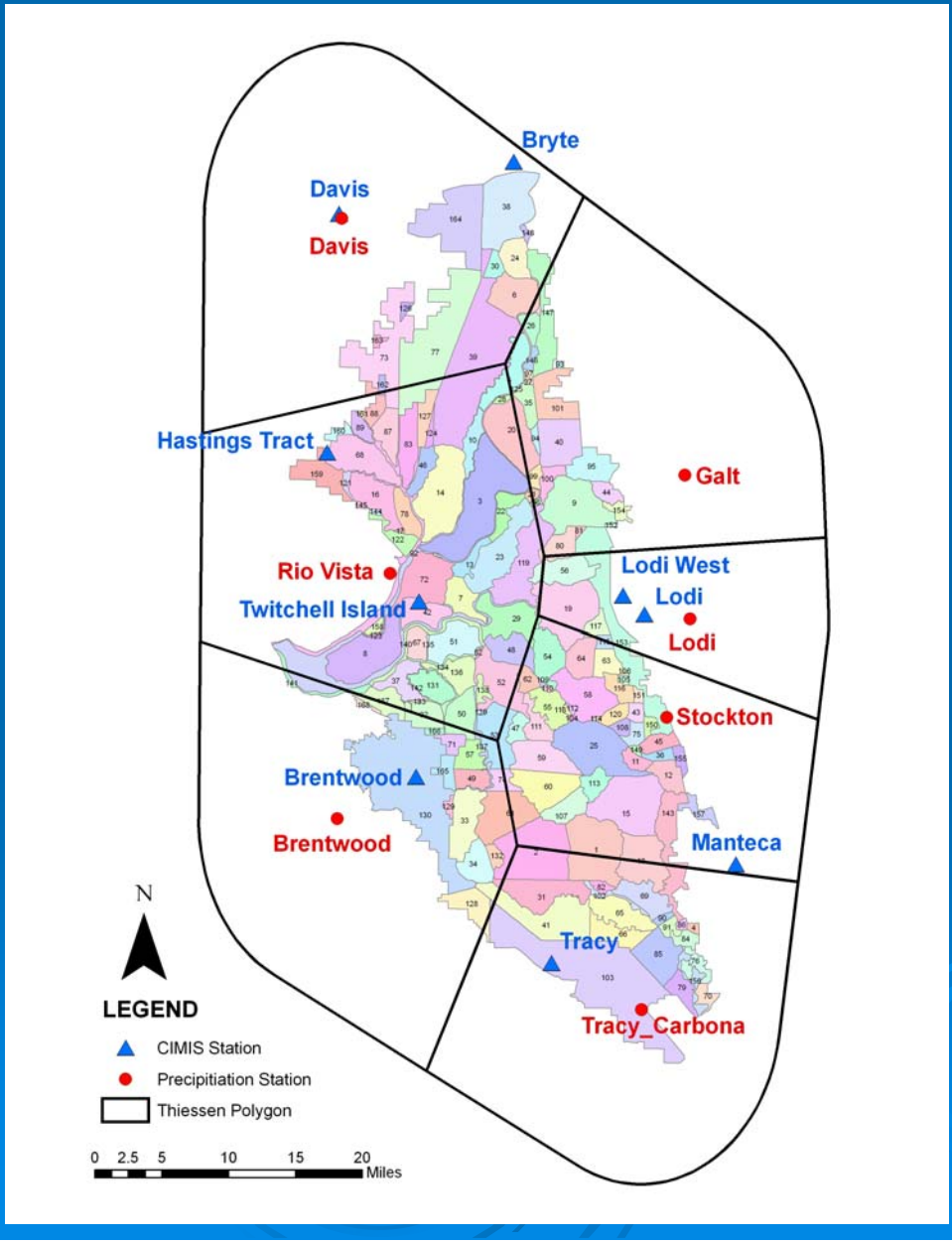
168 Subareas



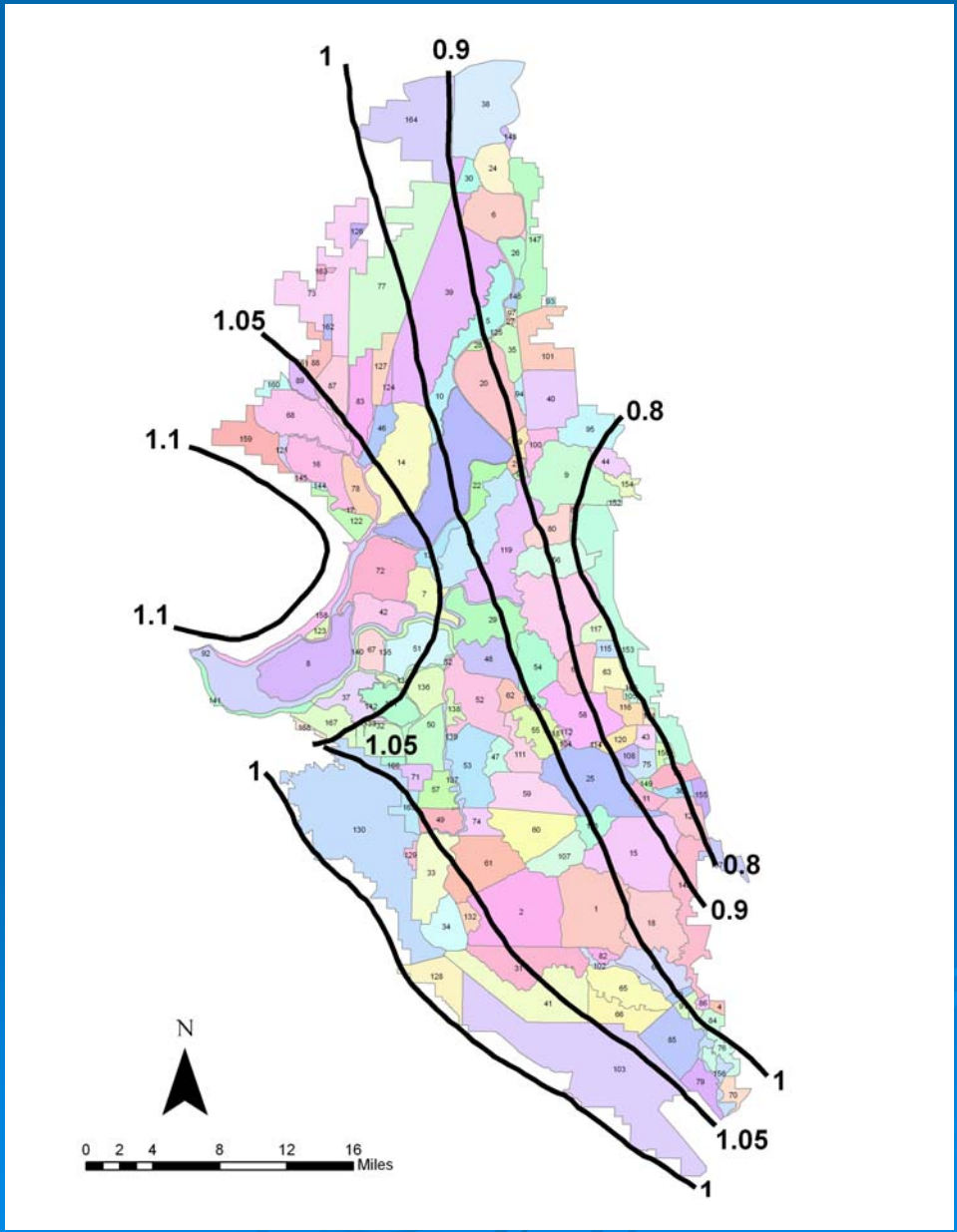
168 Subareas

SUBAREA NAME	ORIGINAL SUBAREA	TEMP SUBAREA	NEW SUBAREA	REGION
UNION ISLAND (EAST)	1	1	1	Lowlands
UNION ISLAND (WEST)	2	2	2	Lowlands
GRAND ISLAND	3	3	3	Lowlands
MOSSDALE	4	4A	4	Uplands
MERRITT ISLAND	5	5	5	Lowlands
LISBON DISTRICT	6	6	6	Lowlands
ANDRUS ISLAND (LOWER)	7	7	7	Lowlands
SHERMAN ISLAND	8	8	8	Lowlands
SUTTER ISLAND	10	10	10	Lowlands

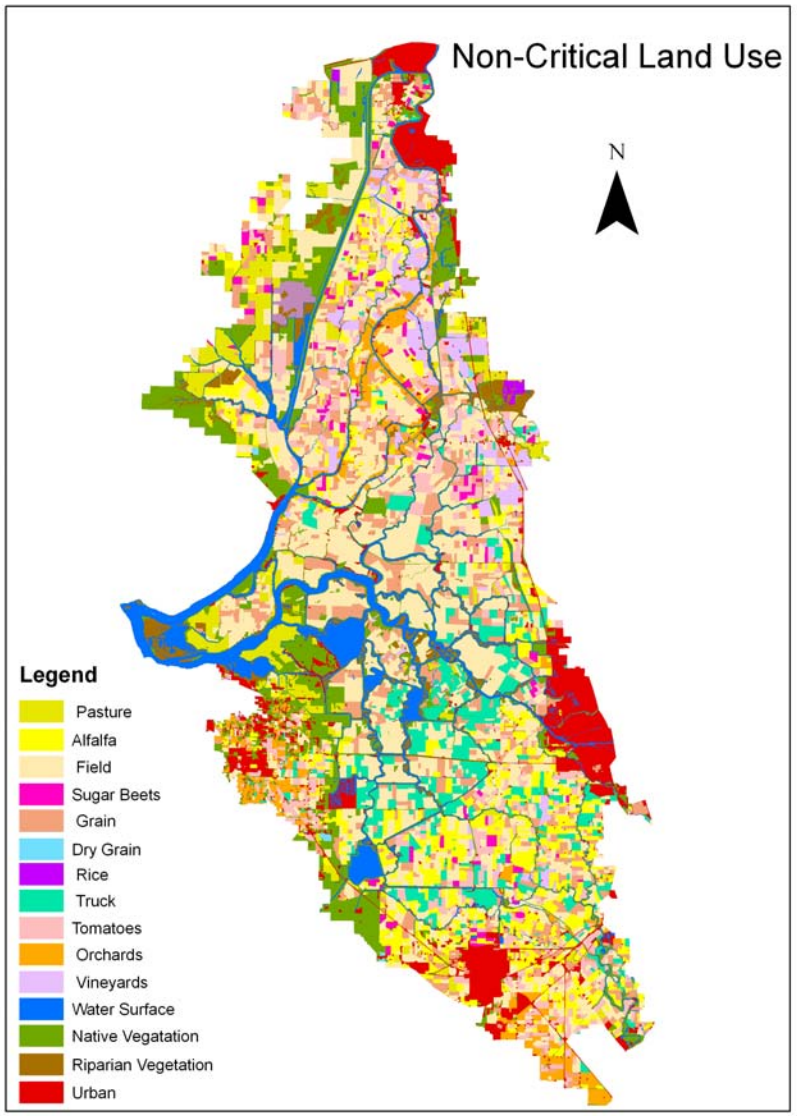
Thiessen Polygons, CIMIS & Precip Stations



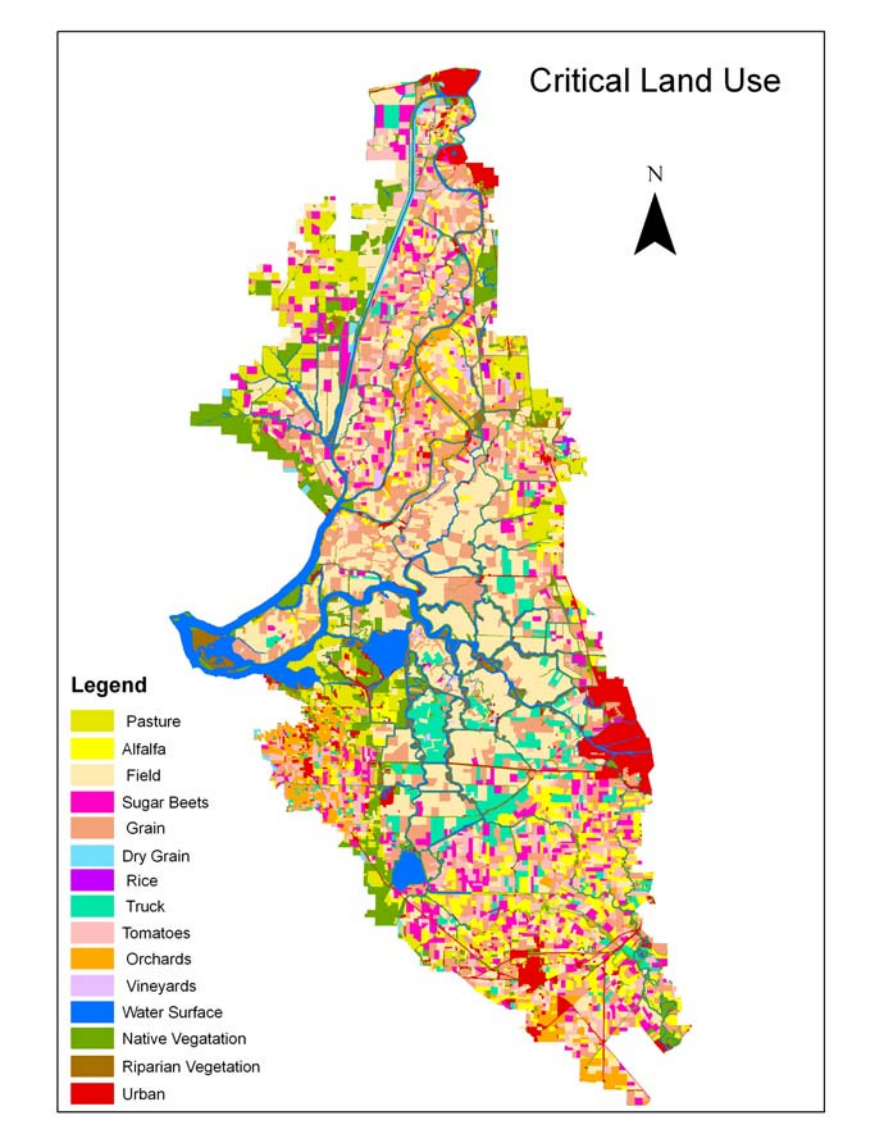
Correction Factor Isolines (H-S to P-M)



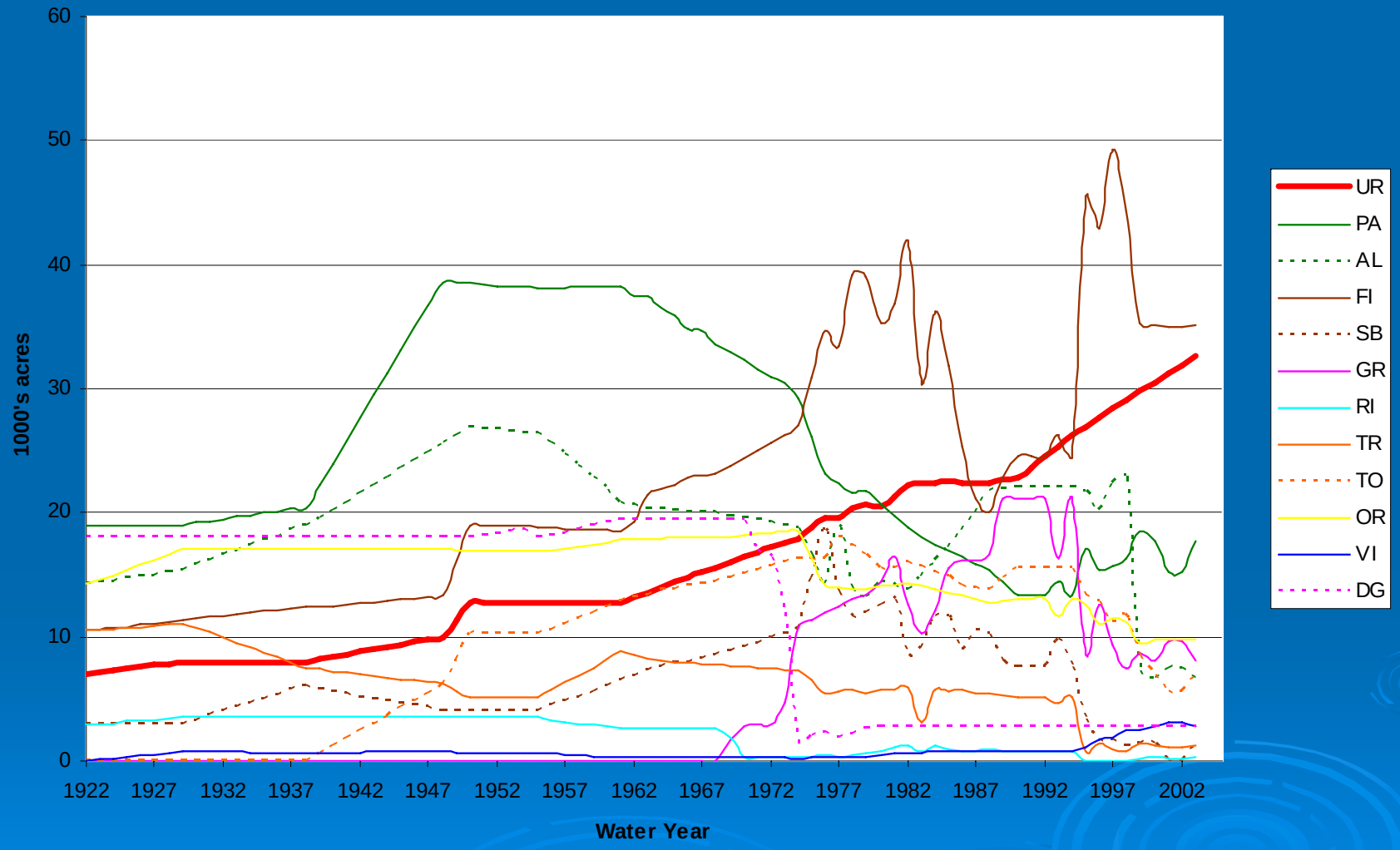
Non-Critical Year GIS Land Use (1990-2000)



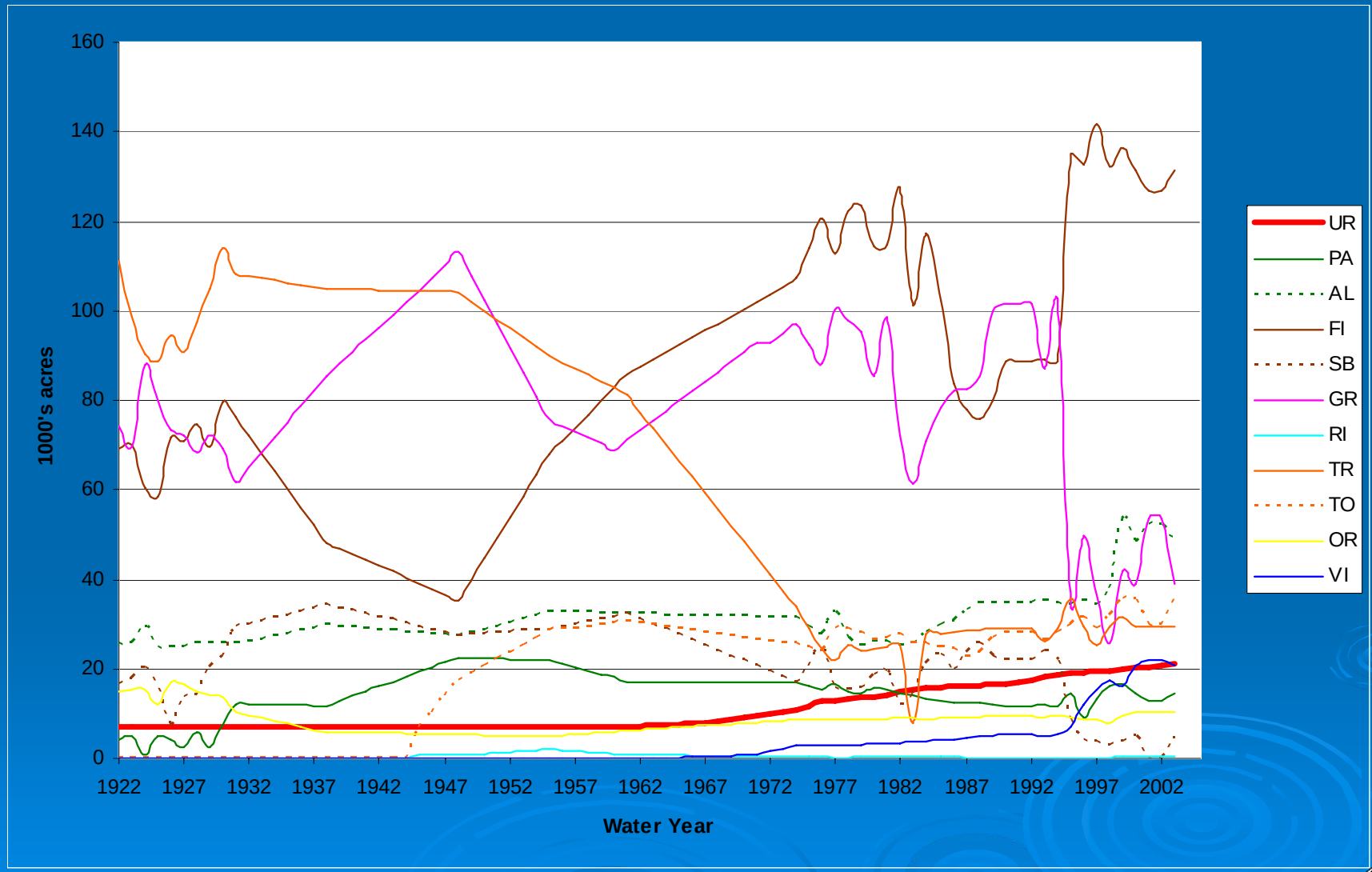
Critical Year GIS Land Use (1976)



Delta Uplands Annual Crop Acreages



Delta Lowlands Annual Crop Acreages



Crop Codes (DPLA vs Bul-160 vs DICU)

- DPLA vs. Bul-160 vs. C2VSIM
- GIS vs. DICU (DETAW)

Bay-Delta Office, Department of Water Resources

Update Data Files | Calculate | Output Files | Statistics | User Guide | Help | Help About

DETAW

Delta Evapotranspition of Applied Water

Bay-Delta Office, Department of Water Resources

- Update Input Data Files
- Calculate Water Balance
- Calculate H. LL/UL Sum
- Calculate P. LL/UL Sum
- Calculate D. Water Balance
- View Weather Output
- View Water Balance Output

Developed by California Land and Water Use, Department of Water Resources

And

Department of Land, Air and Water Resources, University of California, Davis

California Land and Water Use
Department of Water Resources

Land, Air and Water Resources
Department of Water Resources

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DETAW Main Menus

- Update Data Files
  - Weather Data Files
  - Crop/Soil Data Files
- Calculate
  - Historical Soil Water Balance
  - Projected Soil Water Balance
  - Monthly Total Water Balance
  - Historical LL/UL Sum
  - Projected LL/UL Sum
  - Daily Water Balance

DETAW Main Menus (continued)

- Output Files
  - WRK by SA: daily weather
  - MWD by SA: monthly weather
  - CSV by SA: daily water balance
  - MTV by SA: monthly total of daily water balance
  - EAW by SA: seasonal and annual ETAW by each crop
  - SUM MTV by SA: monthly total water balance
  - MTV by LL: aggregated for lowlands by crop
  - MTV by UL: aggregated for uplands by crop
  - Sum by LL/UL: aggregates all crops
  - AFT by SA: daily water balance

Input Data Requirements

- Long-term daily maximum and minimum temperature data from Lodi
- Long-term rainfall data from seven locations surrounding the Delta
- Crop & soil information
- Land-use data from October 1921 through September 2003 (WY1922-2003) aggregated by Uplands and Lowlands

DETAW Output

- Daily ET_o and rainfall rate data for 168 sub areas
- Daily ET_o, K_c, ET_c, and water balance calculations for 15 land-use categories and 168 sub areas.
- Daily, monthly, and annual $ET_{c,}$, Net Applied Water, and ET_{aw} values for 15 land-use categories and 168 sub areas for WY1922 through 2003

DETAW Output
(continued)

- Monthly ET_c , Net Applied Water, and ET_{aw} data by land-use category for the Delta uplands, lowlands, and the entire Delta for WY1922-2003

- Calculated seasonal and annual total of ET_c and ET_{aw} for WY1922-2003

Delta Weather Data

- Long-term daily maximum and minimum temperature data from Lodi
- Long-term precipitation data from seven stations surrounding the Delta

Crop & Soil Input

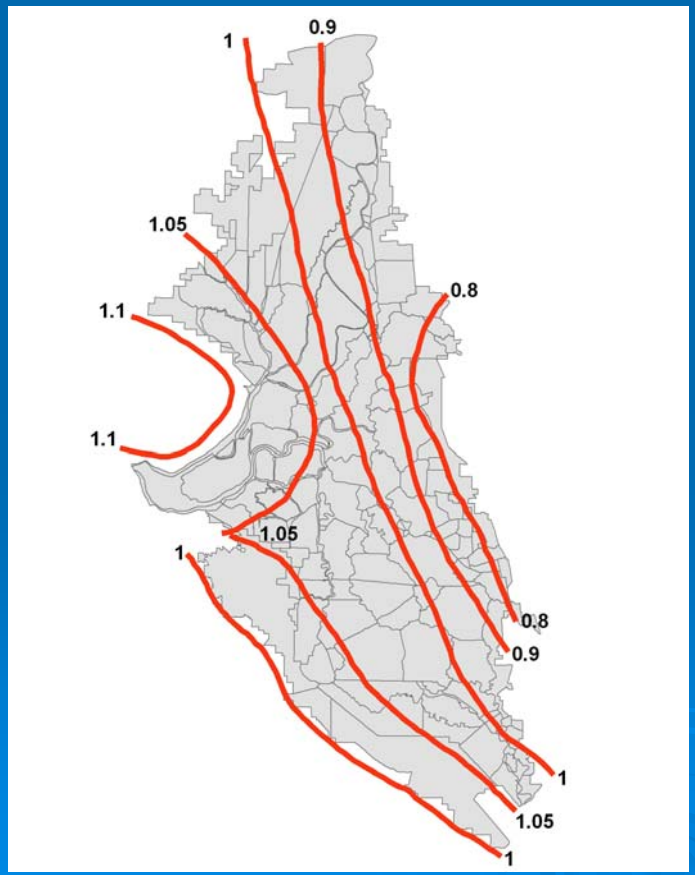
- Land-use category
- Start and end dates
- Maximum rooting depth
- Land-use category data were weighted for the proportion of crops and other surfaces within each category (e.g, for K_c crop coefficients)

Crop & Soil Input
(continued)

- Maximum soil depth = 60 inches
- Available water holding capacity
  - Lowlands 0.22 in./in.
  - Uplands 0.16 in./in.
- Allowable depletion (50%)

Reference Evapotranspiration (ET_o)

Hargreaves-Samani Equation - Lodi

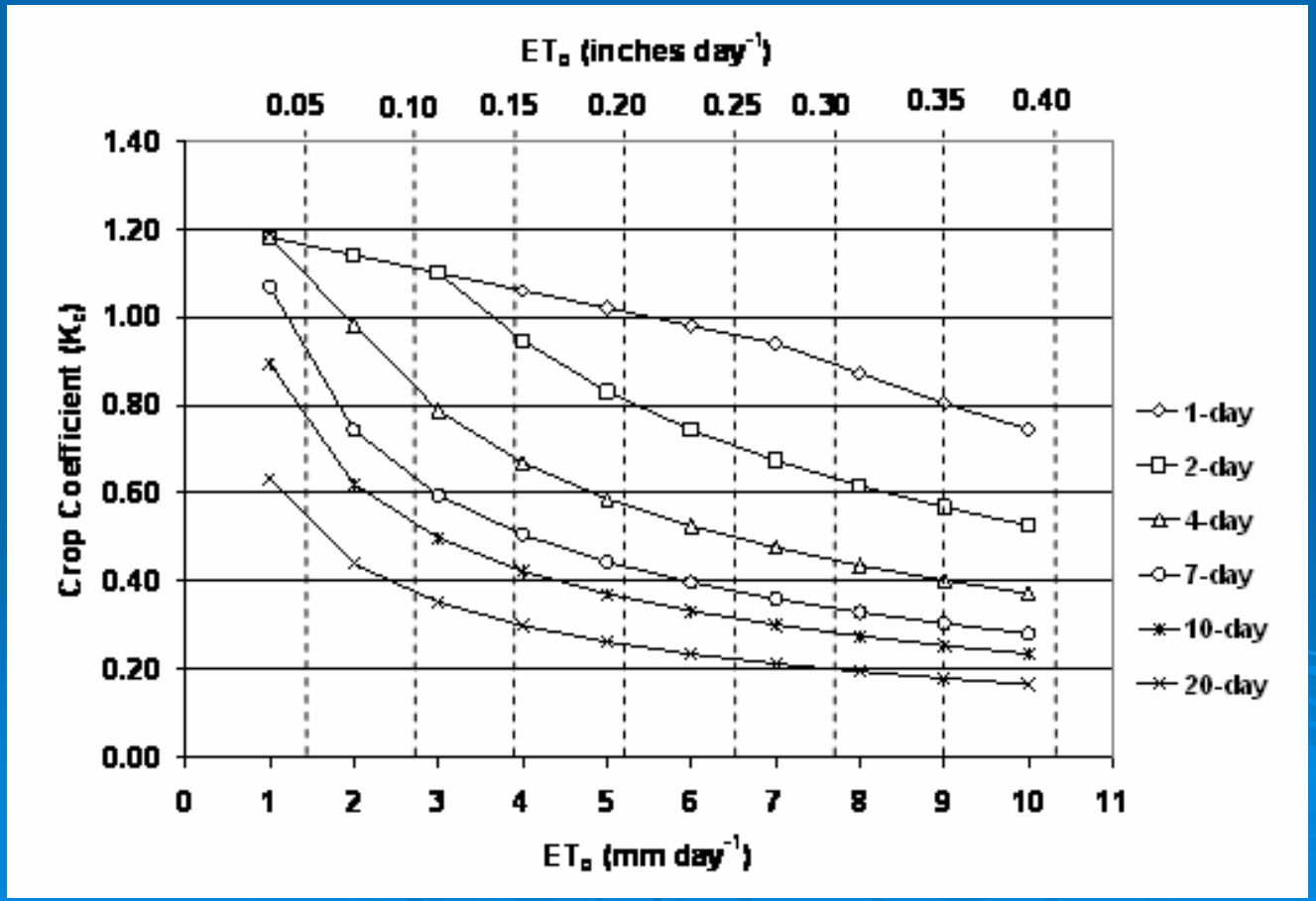


Using HS estimated ETo from Lodi and Penman-Monteith (PM) ETo estimates from 9 CIMIS stations, isolines of correction factors to estimate PM ETo from Lodi HS ETo were developed. Then GIS was used to estimate correction factors for each sub area within the Delta.

Crop Coefficients

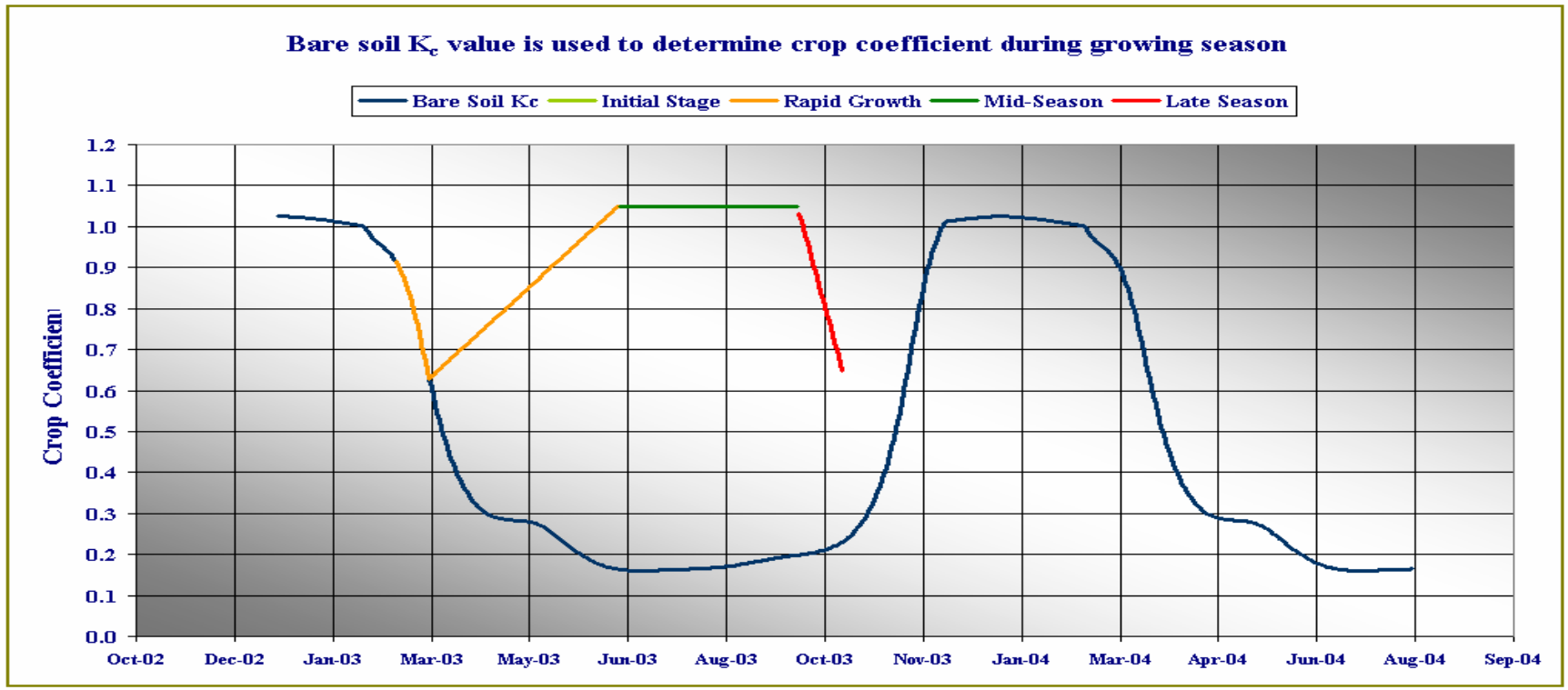
Off-season (bare soil) K_c

Depends on ETo rate and wetting frequency.



Crop Coefficients
(continued)

Bare-soil evaporation during the off-season is used to estimate initial K_c



Daily Water Balance

Yield Threshold = Allowable Depletion x Plant Available Water

Plant Available Water = Available Water-holding Capacity x Effective Rooting Depth

Daily Water Balance
(continued)

Off-season maximum depletion
(50% of PAW in upper 30 cm)

Soil water Depletion = Field Capacity - Soil Water Content

Daily Water Balance
(continued)

- Effective Seepage
  - if S_{pg} > SWD then E_{spg} = SWD
  - If S_{pg} < SWD then E_{spg} = S_{pg}
- Effective rainfall
  - If P_{cp} > SWD then R_e = SWD
  - If P_{cp} < SWD then R_e = P_{cp}
- Irrigate when (SWD + D_{sw}) > SWD_x

D_{sw} and NA

$$D_{sw} = ET_c - E_r - E_{spg}$$

Net Application

- If SWD' + D_{sw} > SWD_x then NA = SWD' + D_{sw}
- If SWD' + D_{sw} < SWD_x then NA = 0

SWD' = soil water depletion on the previous day

SWD_x = max allowed soil water depletion

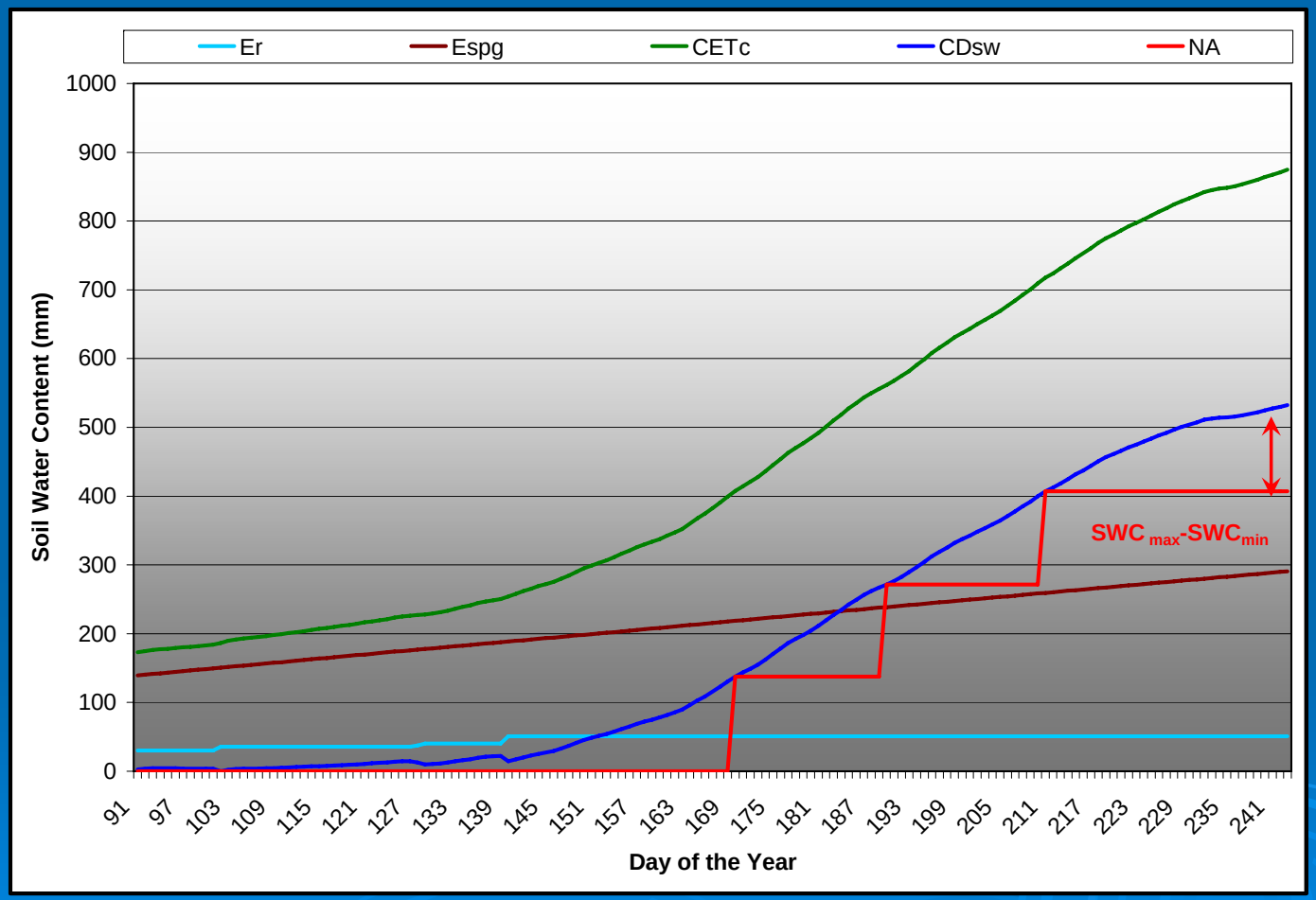
ET_{aw}

- Daily calculations
- Sum of D_{sw} – ΔSWC over season

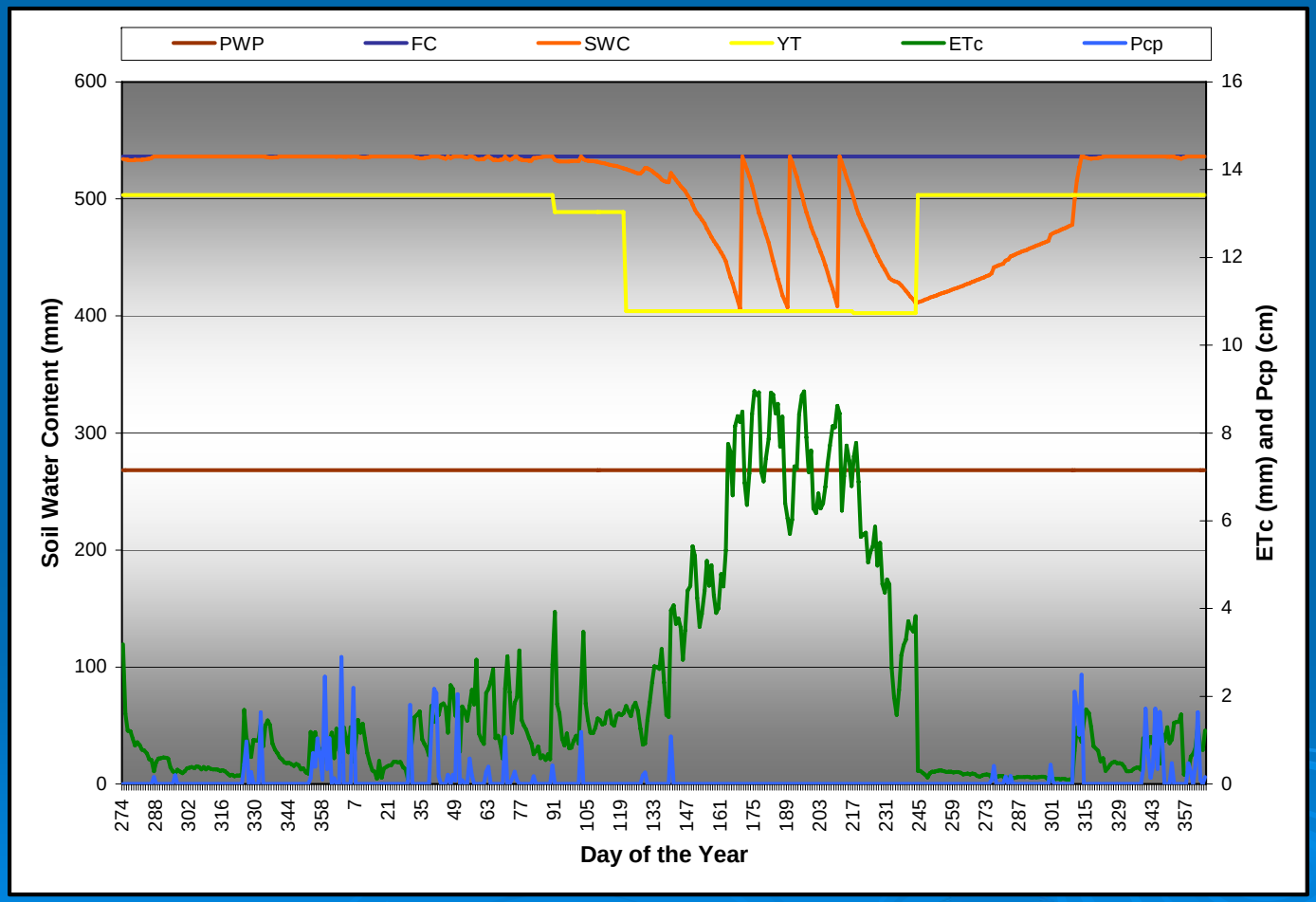
or

- Sum of NA over season

A Plot of Cumulative ET_c, E_r, and E_{spg} for Tomatoes in Subarea 1 During Growing Season in 1922



One-year Water Balance for Tomatoes in 1922 Subarea 1



Example of Daily Water Balance

- Daily Water Balance

Extra Features

- Allows one to easily update input weather data files
- Includes a large database of climate data
- Allows easy input of crop and soil information

DETAW Demonstration

- DETAW mpeg

Preliminary Results and Comments

- Daily and monthly net application, runoff, etc values for the period WY1922-2003
- Values for both historical and projected levels of land use development
- Verification of numbers under way
- Very I/O intensive (14,000 files and ~15GB storage space)

Summary

- GIS-based map with 168 subareas in the Delta
  - All areas nested 168→ 142→ Delta UL/LL→ Delta
- DETAW: C^{++} GUI based on SIMETAW
- Preliminary numbers for daily water balance for each crop for each of the 168 subareas for WY 1922-2003
- Additional work underway to verify numbers and streamline the DETAW I/O requirements

Special Acknowledements

- Sarah Sareshteh (UC Davis): C++ Programming
- Mary Serrato (CA DWR): GIS Digitizing and Spatial Analyses
- Mahmoud Mabrouk (CA DWR): Land Use, Precipitation, and Temperature
- Jim Wilde (CA DWR): DSM2
- Bob Suits (CA DWR): DSM2

Questions?